Hewlett Packard
Enterprise

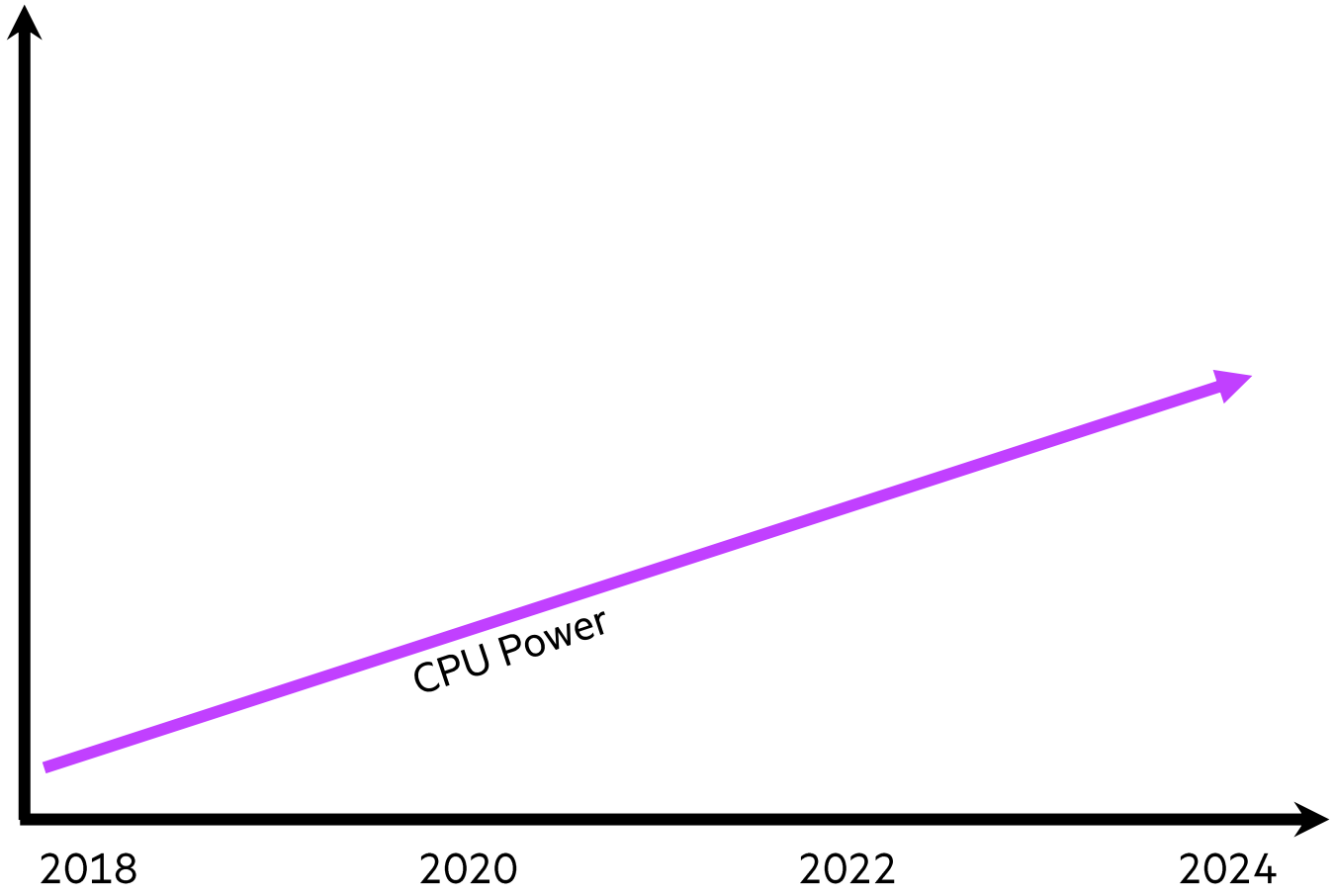
LIQUID COOLING FOR HPC, ENTERPRISE AND BEYOND

HOW HPE THINKS OF ENERGY EFFICIENCY ACROSS THE PORTFOLIO

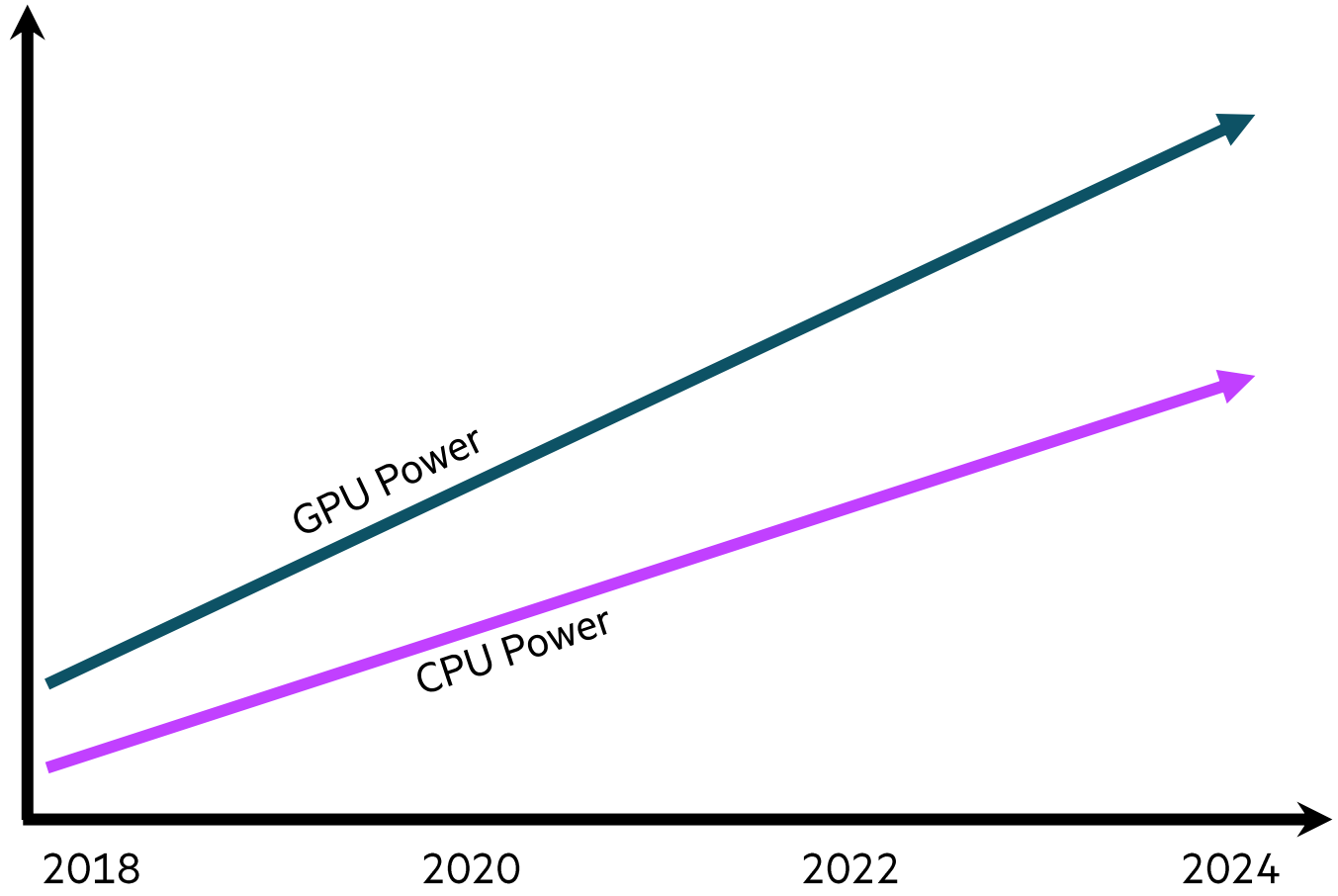
Jason Zeiler, Matt Slaby and Wade Vinson

May 04, 2022

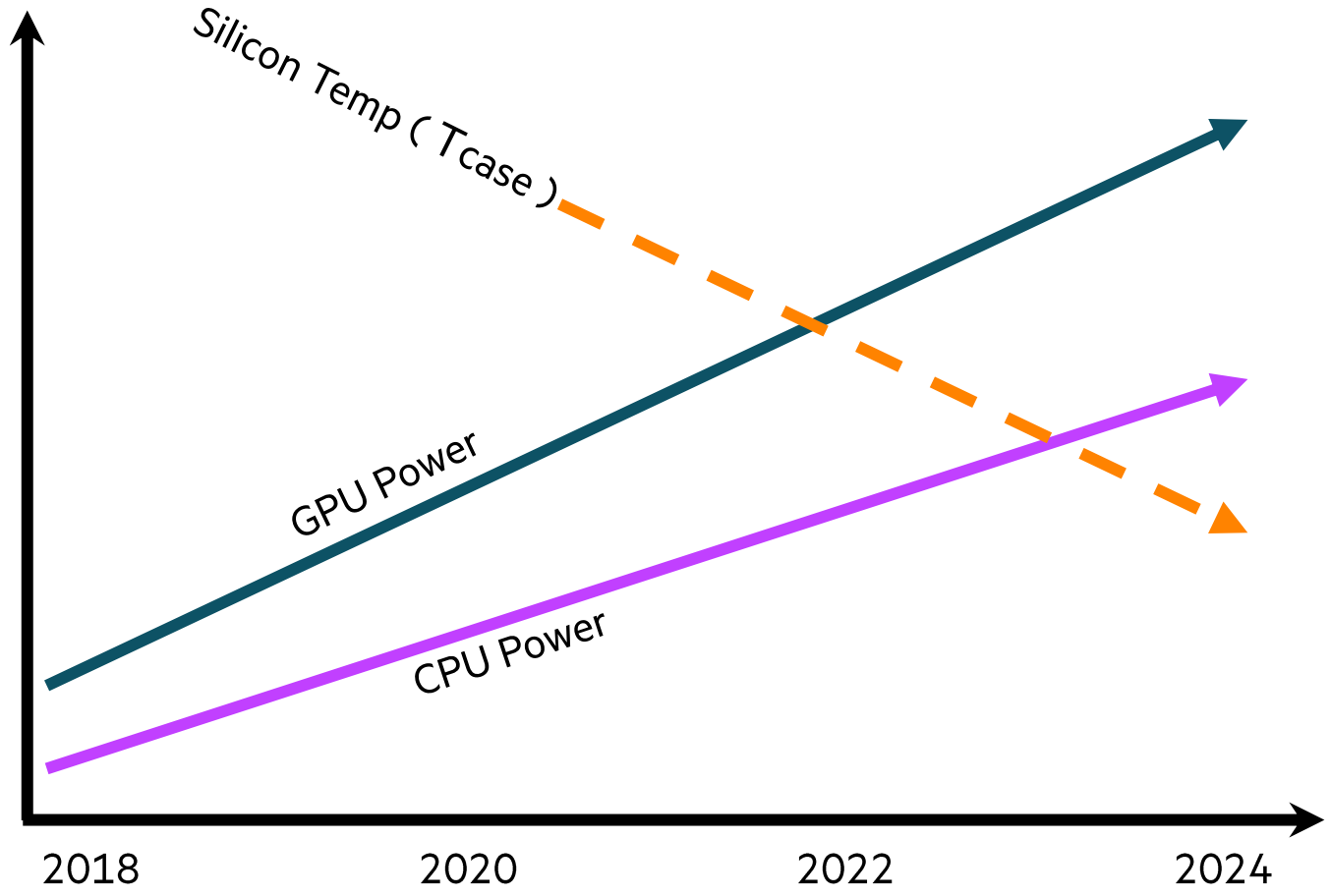
THE COOLING DILEMMA



THE COOLING DILEMMA



THE COOLING DILEMMA



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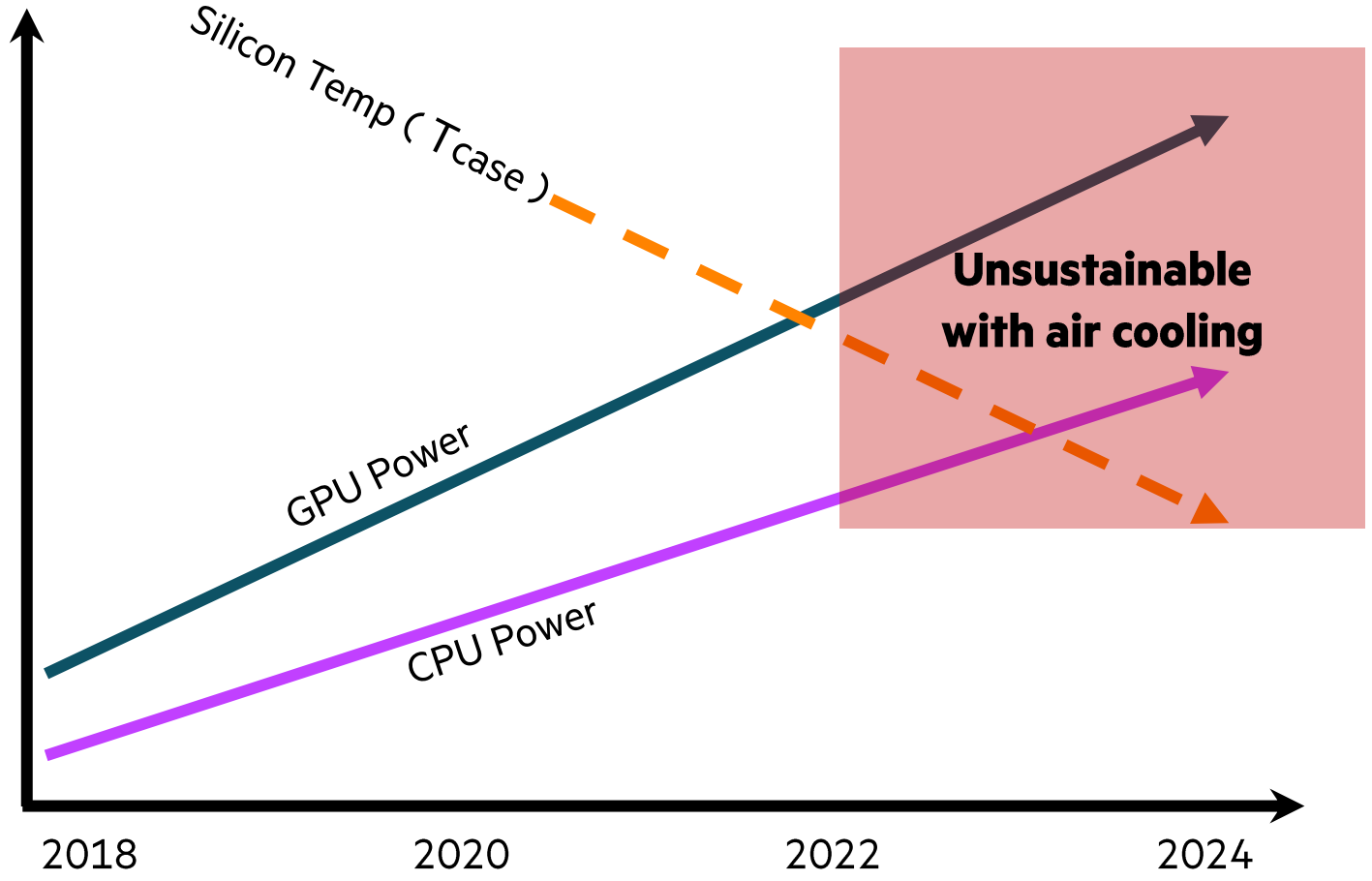


HOW DID DATA CENTER GREEN-NESS BECOME A TARGET?

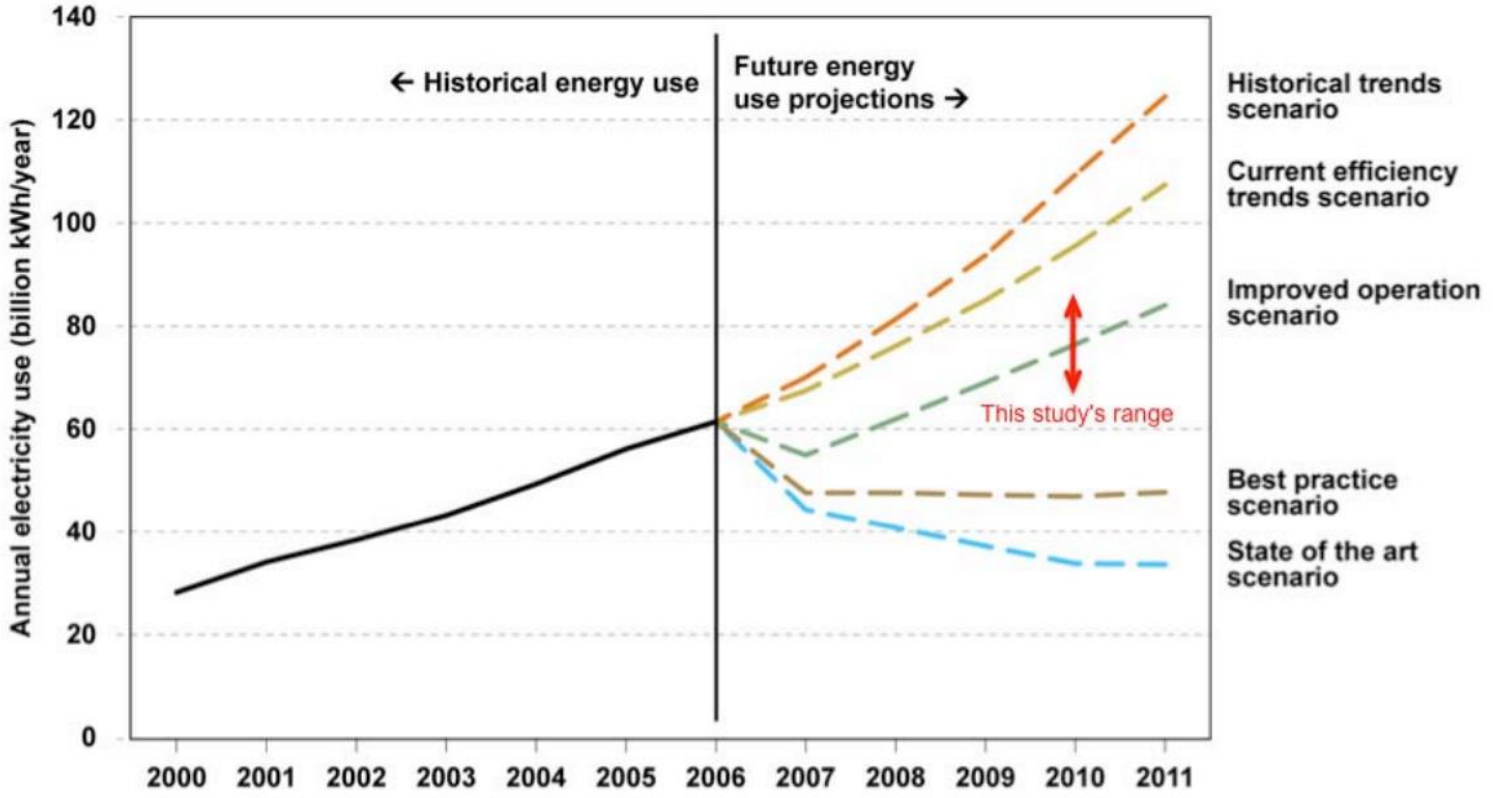
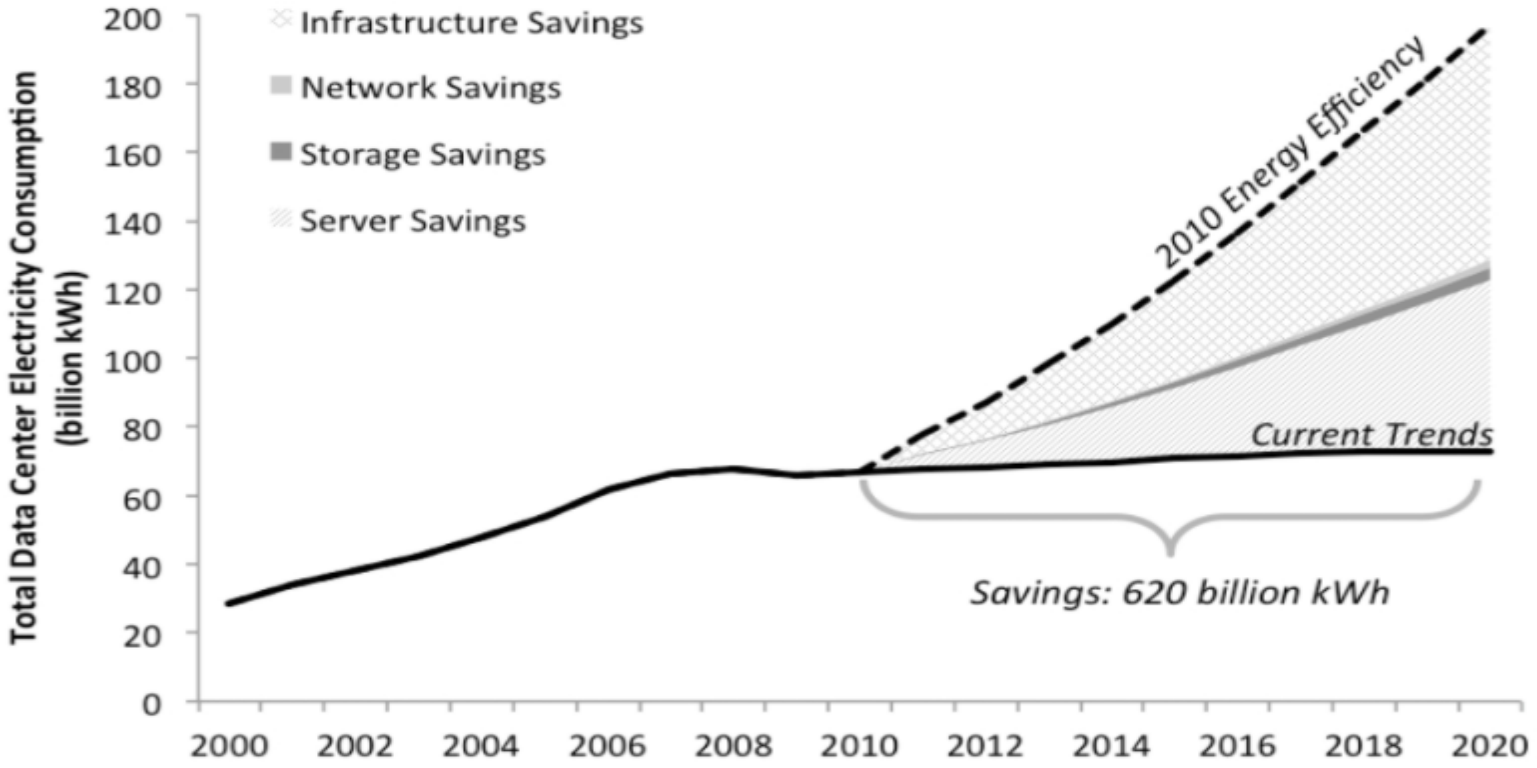


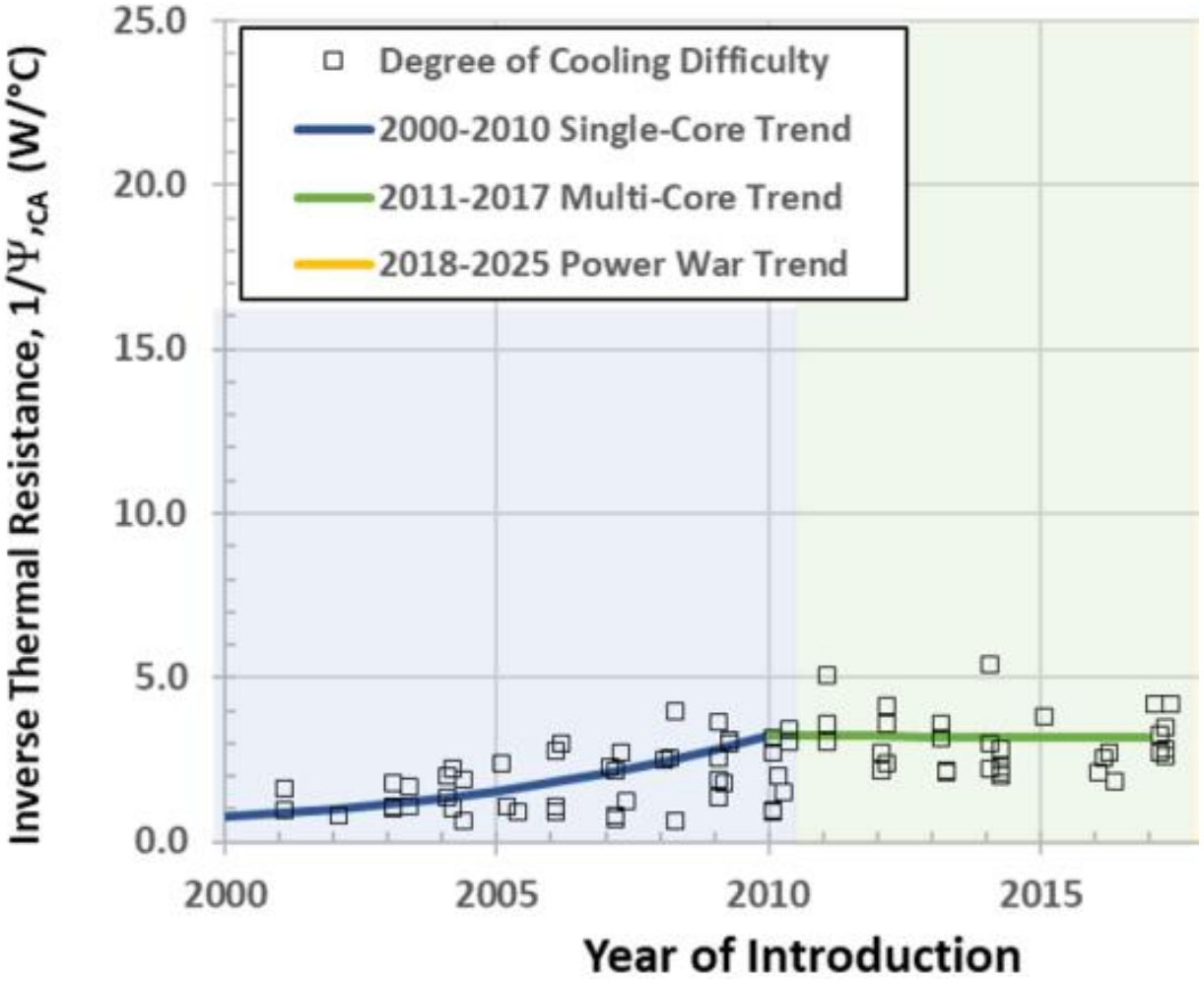
Figure ES-1: Predicted US electricity use for data centers from the EPA report to Congress (EPA 2007) and the range estimated in this study

...WHAT REALLY HAPPENED...2016 REFLECTION



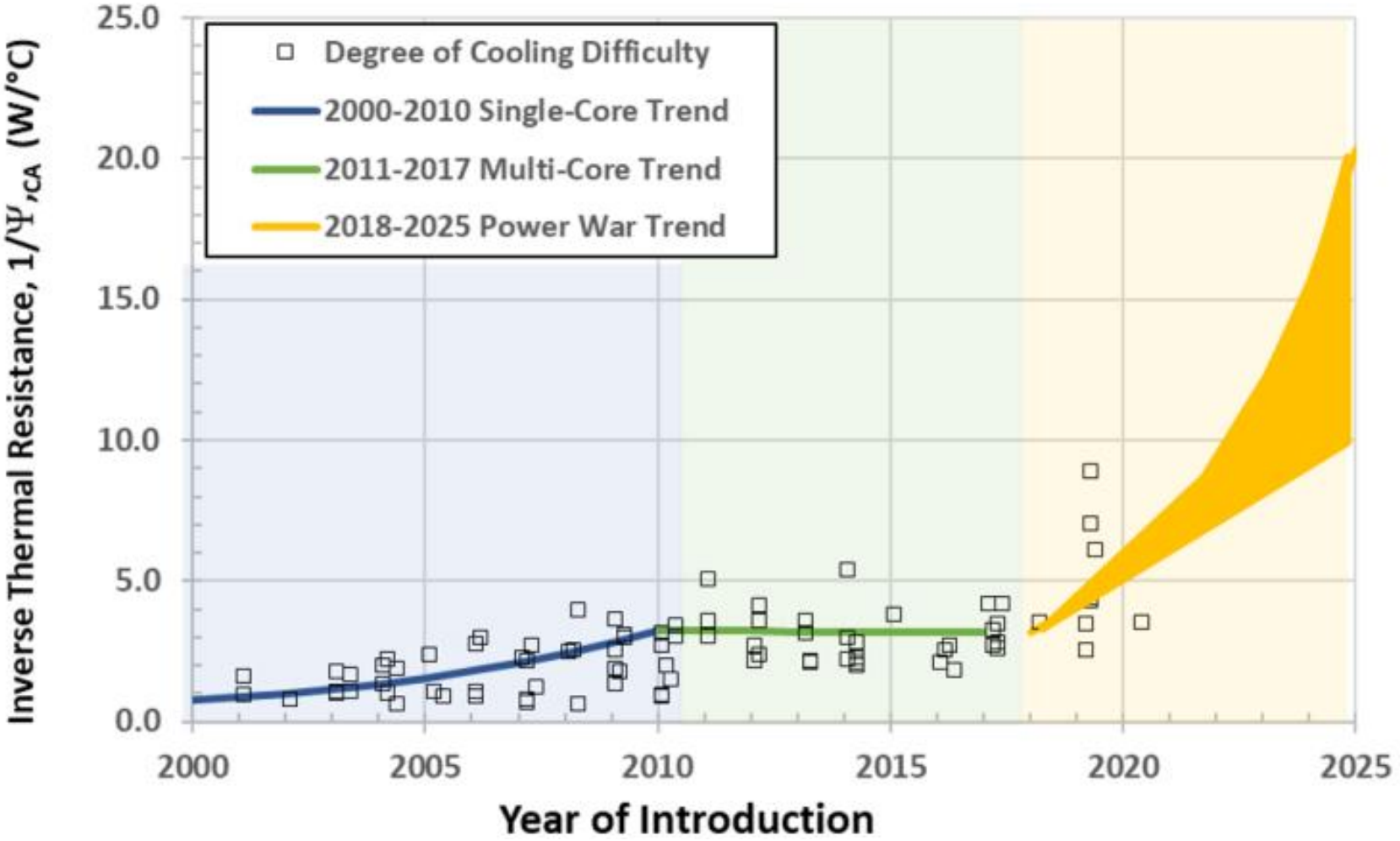
This chart shows past and projected growth rate of total US data center energy use from 2000 until 2020. It also illustrates how much faster data center energy use would grow if the industry, hypothetically, did not make any further efficiency improvements after 2010. (Source: US Department of Energy, Lawrence Berkeley National Laboratory)

CHANGING CHIP DESIGNS



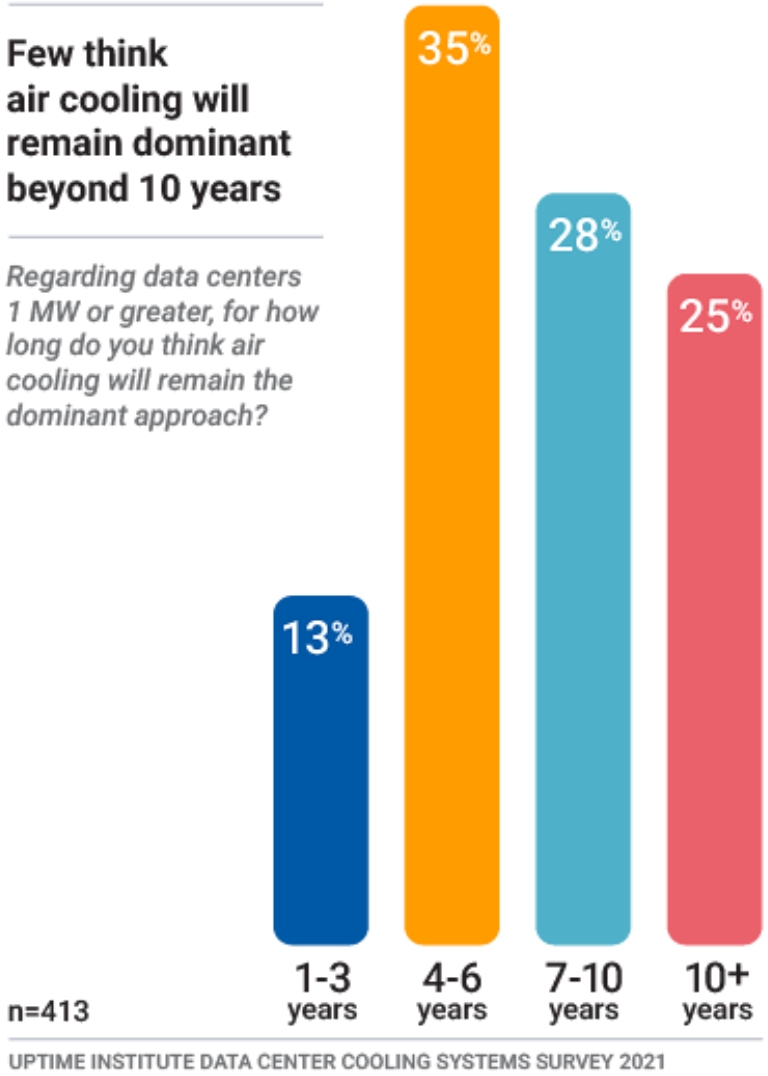
ASHRAE Technical Committee (TC) 9.9, Mission Critical Facilities, Data Centers, Technology Spaces, and Electronic Equipment White Paper: Emergence and Expansion of Liquid Cooling in Mainstream Data Centers

COOLING MATTERS – ITS GOING BACK UP…WITH A VENGEANCE!



ASHRAE Technical Committee (TC) 9.9, Mission Critical Facilities, Data Centers, Technology Spaces, and Electronic Equipment White Paper: Emergence and Expansion of Liquid Cooling in Mainstream Data Centers

LIQUID COOLING ACCEPTANCE IS UNDERWAY



https://journal.uptimeinstitute.com/does-the-spread-of-direct-liquid-cooling-make-pue-less-relevant/

COOLING MATTERS WITH CHANGING INDUSTRY MANDATES

JPMorgan Joins Net-Zero Bank Alliance With Emissions Pledge

“We are joining the Net-Zero Banking Alliance because we support the ambition for greater climate action, the sharing of best practices and a collaborative approach between the public and private sectors to reach this goal,” Buchanan said in her statement. “Thoughtful policy, technology and behavioral advancements are all prerequisites in realizing our common goals around net-zero emissions by 2050.”

https://www.bloomberg.com/news/articles/2021-10-08/jpmorgan-joins-net-zero-banking-alliance-with-emissions-pledge

ENERGY EFFICIENCY IS STANDARD

Liquid to Air Cooling

Chilled water supply from the facility cools down the air-cooling system positioned close to the servers.

RDHX
Rear Door
Heat Exchanger

ARCS
Adaptive Rack
Cooling Solution

Hybrid Cooling

Combined direct liquid cooling and air cooling

Apollo DLC

Direct Liquid Cooling

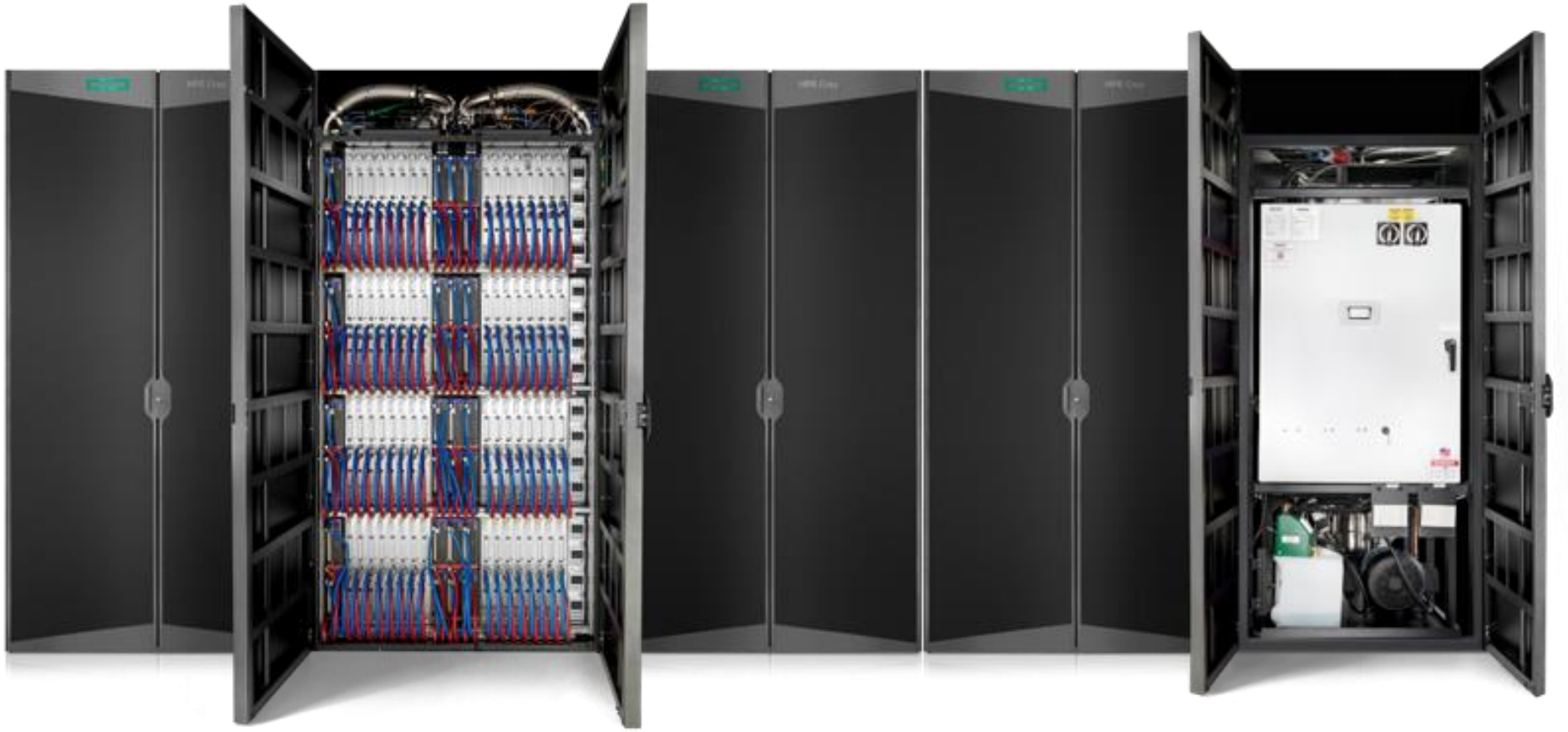
Coolant flows through a network of tubes and coldplates to extract heat directly from all components on the server

Cray EX Lite

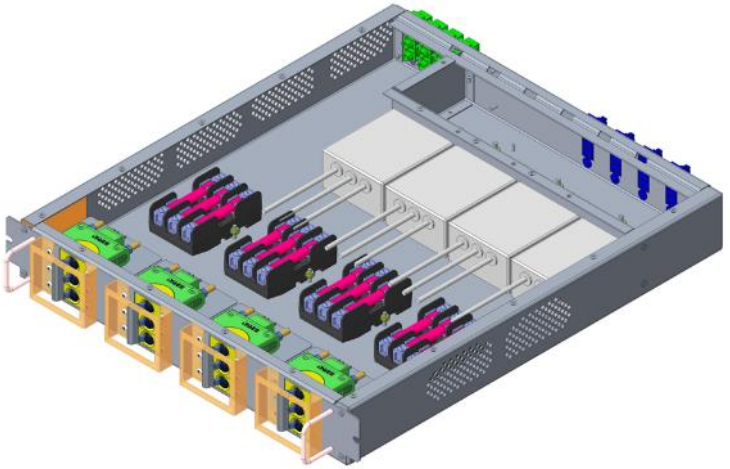
Cray EX

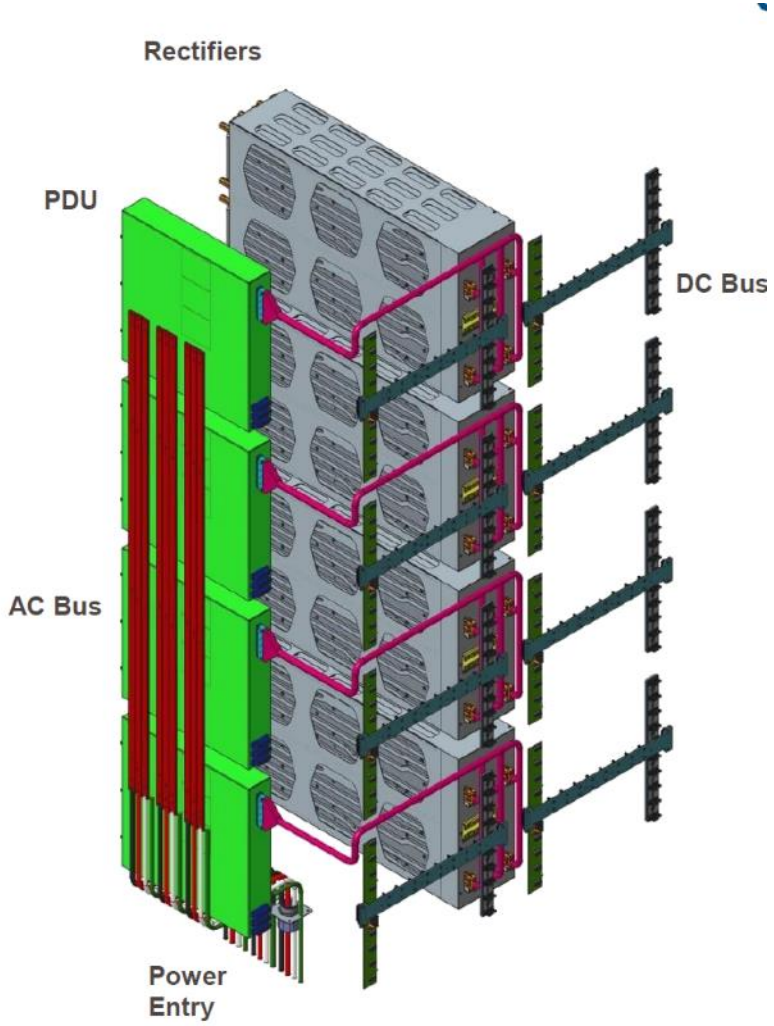
Cooling efficiency and capacity (kW/rack) increases from left to right

HPE CRAY EX4000 - EXASCALE, BUT ALSO EXTREME ENERGY EFFICIENCY

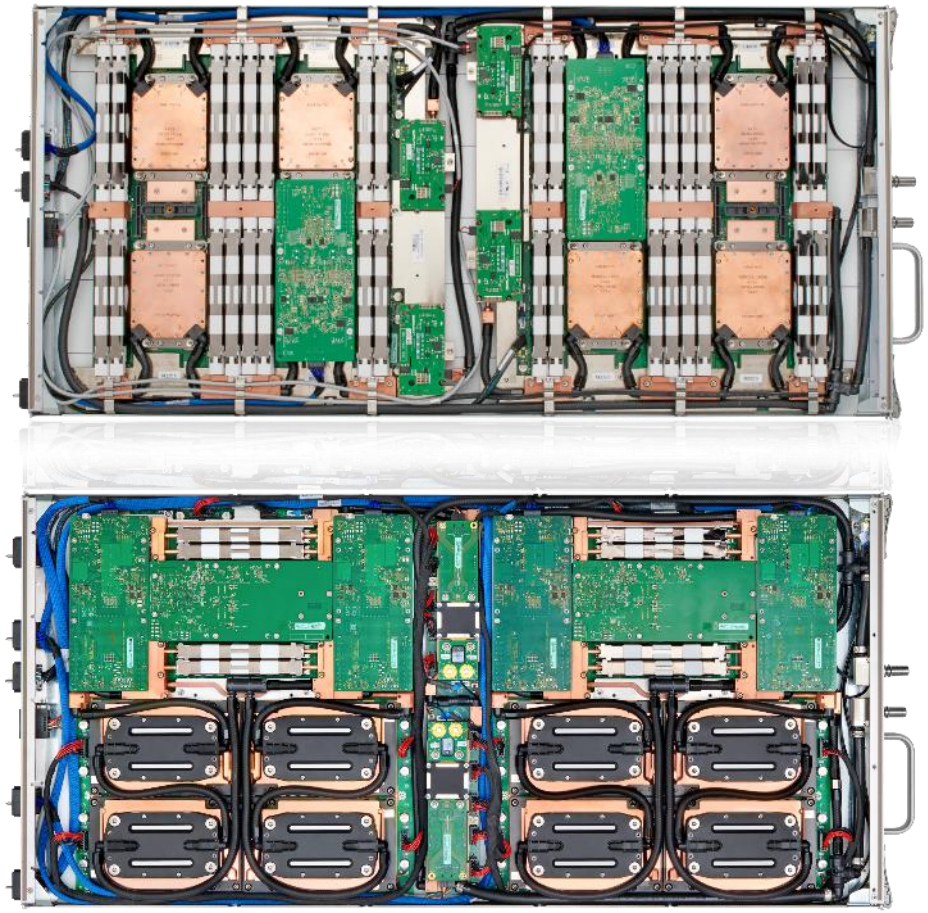


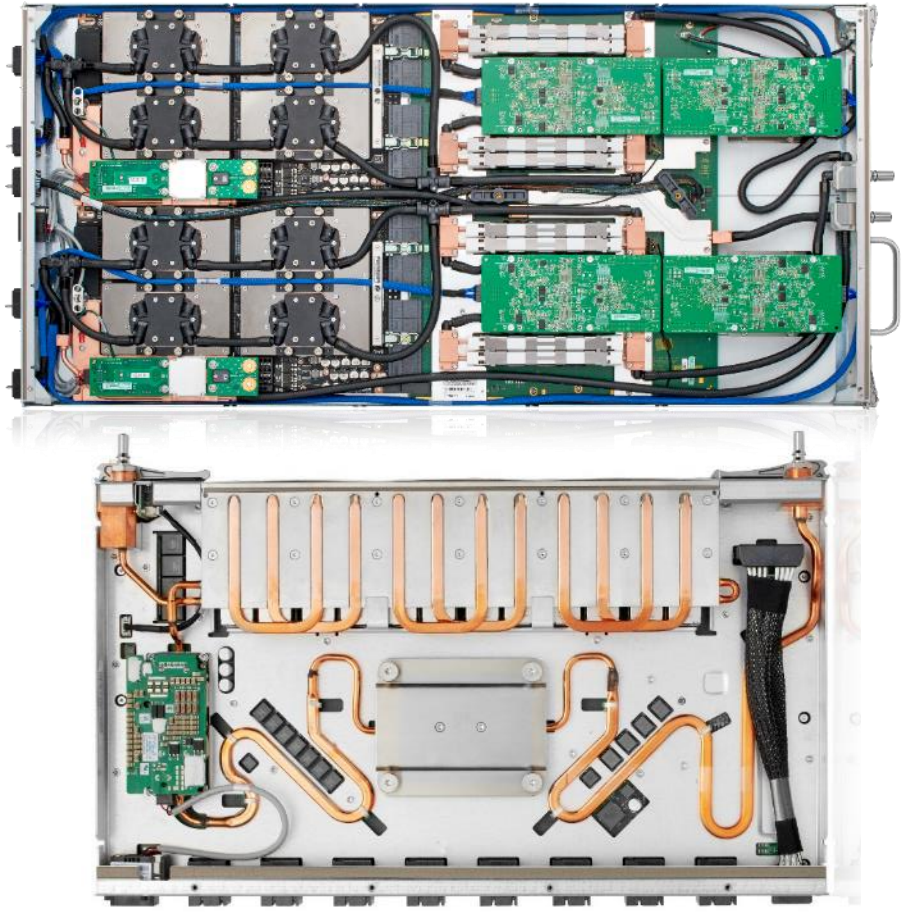
RACK AND ROW SCALE - EXTREME ENERGY EFFICIENCY





BLADE SCALE - EXTREME ENERGY EFFICIENCY



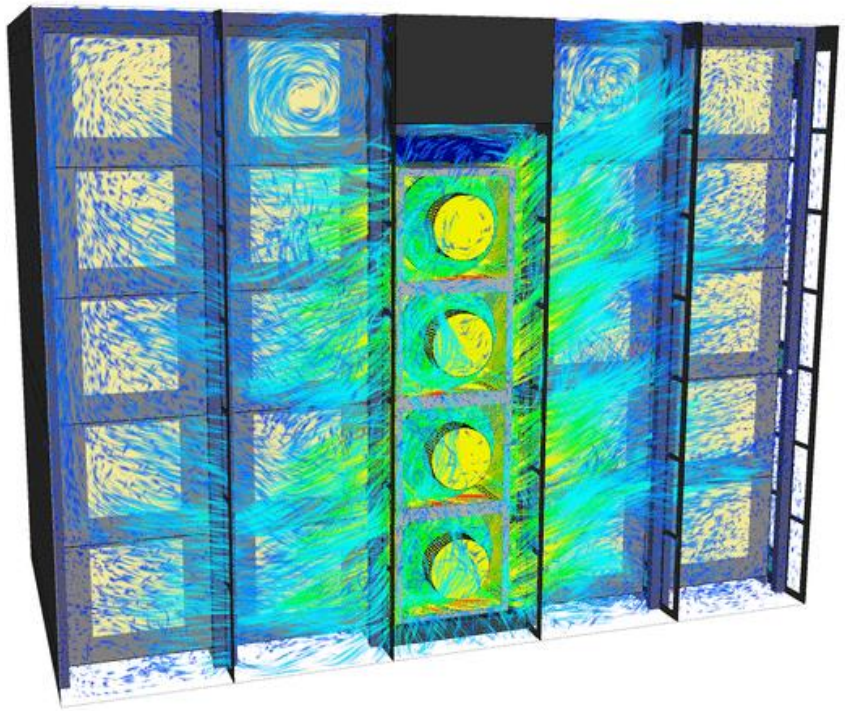


HPE CRAY EX2500 – RACK SCALABLE SUPERCOMPUTING

SUPPORT RACKS WITH 100% LIQUID COOLING

ARCS

with Apollo or ProLiant



OR

ARCS

with Apollo DLC

DATA CENTER TCO SCENARIOS

TCO Model with standard air-cooled data center

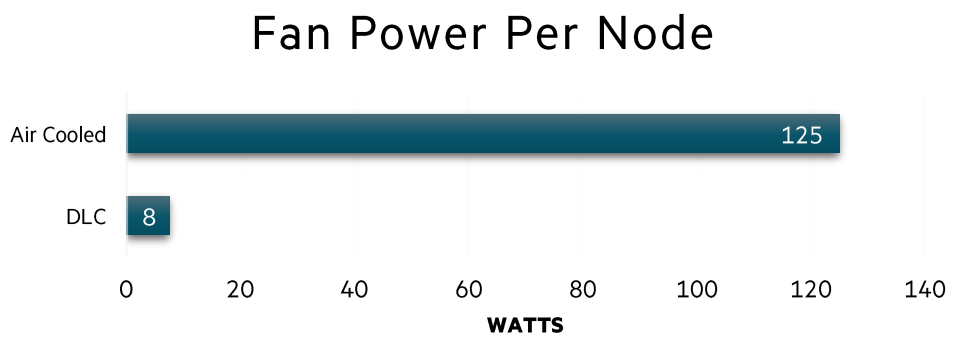
- 1.2 and 1.45 PUE for air cooled loads
- 1.1 PUE for direct liquid cooled loads

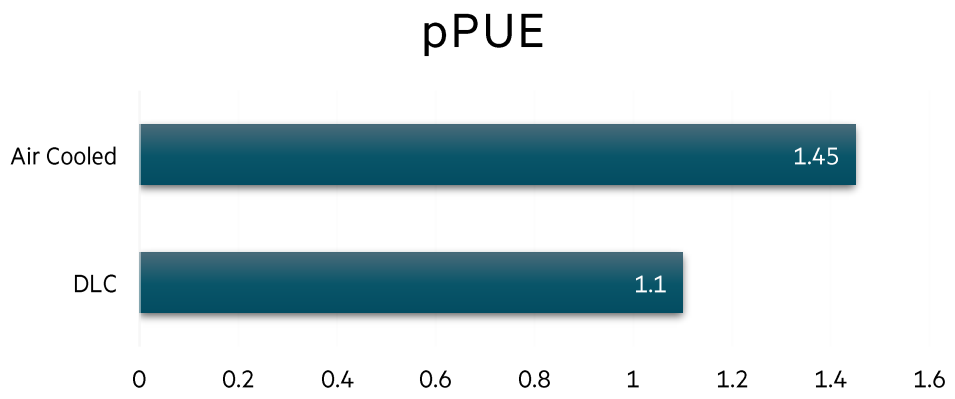
72 air cooled and 72 DLC servers in a rack in the HPE Apollo 2000 Gen 10+

Liquid cooling pay back was a positive ROI with paybacks between 218 and 578 days

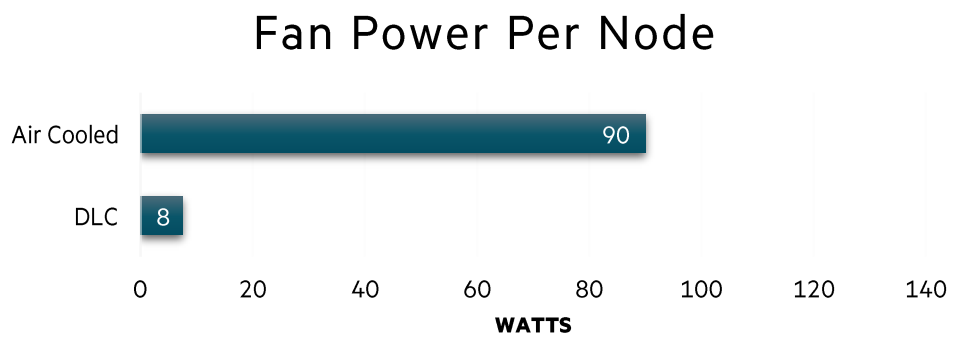
DATA CENTER TCO - NODE TO AMBIENT COOLING

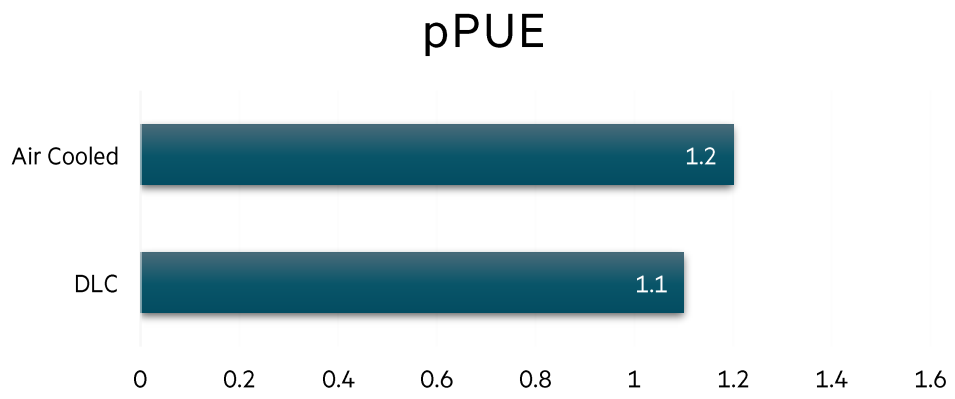
Scenario #1 - 280W processor





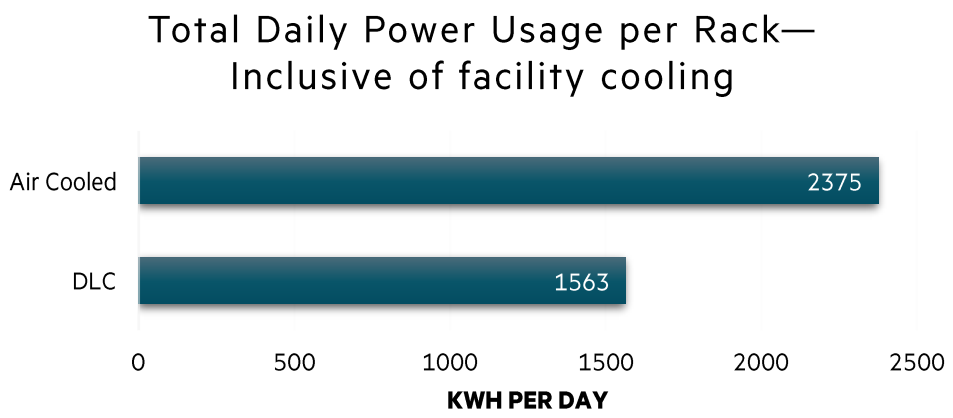
Scenario #2 - 240W processor





DATA CENTER TCO - DAILY RACK POWER USAGE

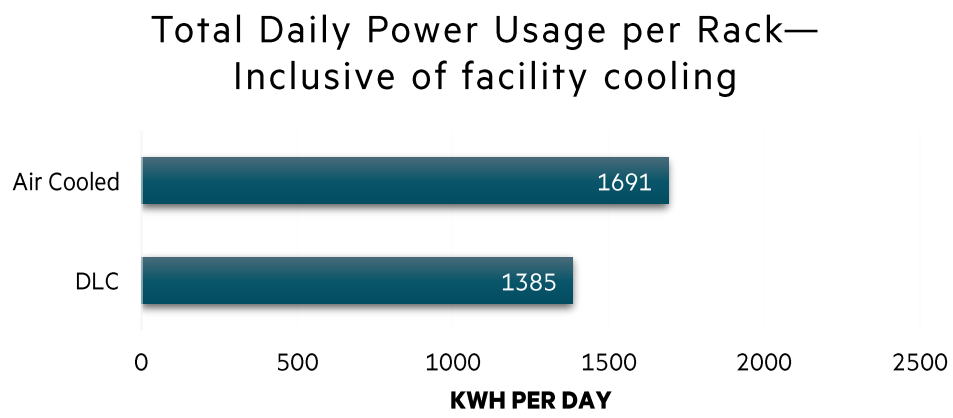
Scenario #1 - 280W processor



DLC Saves $130 a day in electricity costs

Investment in DLC pays back in 218 days

Scenario #2 - 240W processor



DLC Saves $49 a day in electricity costs

Investment in DLC pays back in 578 days

Assumes $0.16 per kWh

1.45 PUE assumes datacenter with constant air-cooled chiller operation

1.2 PUE assumes some hours of economized cooling per year

1.1 PUE assumes mostly free cooling throughout the year

SIGNIFICANT SAVINGS IN BOTH POWER CONSUMPTION AND FOOTPRINT

Air cooled data center cooling cost per chassis (chassis fan and datacenter)

- $8.47/Chassis(4 node)/Day

  39kW/rack **NON-Compute** per hour of operation @ 72 nodes per rack

DLC Cooled data center cooling cost per chassis (chassis fan and datacenter)

- $1.38/Chassis(4 node)/Day

  6.5kW/rack **NONCompute** per hour of operation @ 72 nodes per rack

Liquid Cooled Savings

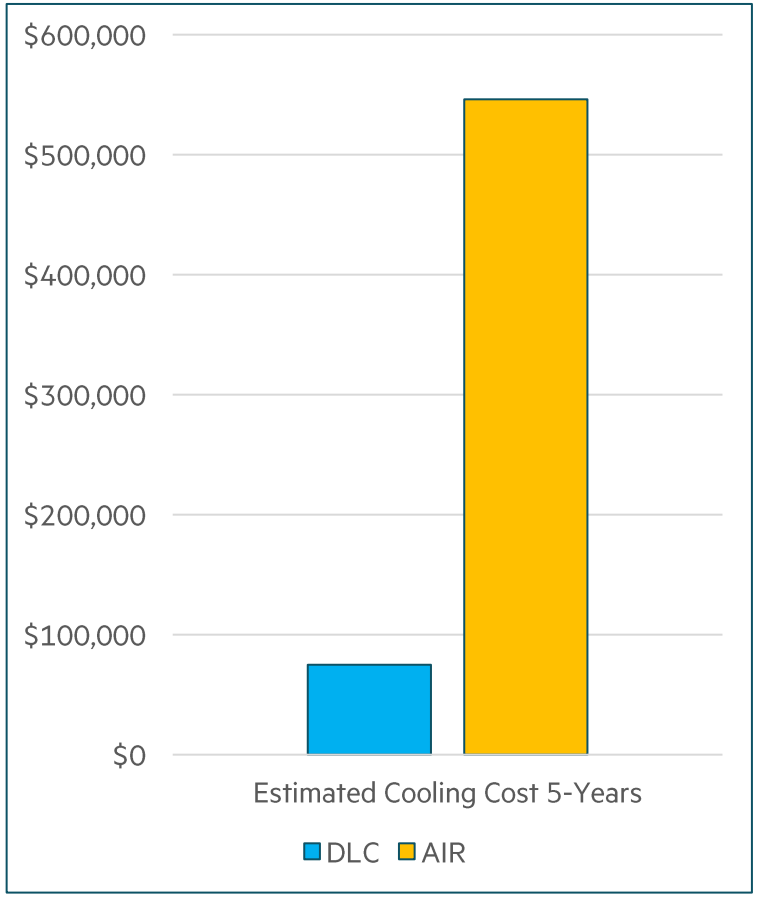
- **$1,398,018 savings per year with 2160 nodes (540 4-node chassis—30 racks)**

Space savings

- **How much CFM can data center support per rack?**
- **72 Nodes = 1700 CFM, 72 Air Cooled = 4700 CFM *Almost 2 more racks***

SMALL 504 NODE "GRID" - DL360 GEN10 COMPARISON TO XL220N DLC

5yr Power Savings – 86% Reduction



Servers			Direct Liquid Cooling			Annual kWh	1-Server	1-Server	504-Servers
DLC/AIR Rack		Watt Per System	Fan Watts	CRAH Watts PPUE	Dry Cooler DLC Watts	kWh	1-Year	5-Years	5-Years
Nodes	Type	100%	1.5%	2%	3%	8760 hr/yr	$0.105 KW/h	$0.105 KW/h	$0.105 KW/h
84	XL220	646.75		12.9	19.4	283	$29.74	$148.72	$74,954.96

Projected Icelake 235W 90% TDP 1TB memory

Site capability to add dry cooler
And plumb DLC and CRAH to it

Servers			Air Cooling			Annual kWh	1-Server	1-Server	504-Servers
DLC/AIR Rack		Watt Per System	Fan Watts	CRAH Watts PPUE	Heat Rejection Watts	kWh	1-Year	5-Years	5-Years
Nodes	Type	100%	8%	10%	20%	8760 hr/yr	$0.105 KW/h	$0.105 KW/h	$0.105 KW/h
18	DL360	620.2	49.6	62.0	124.0	2065	$216.77	$1,083.87	$546,272.46

Cascade lake today 205W 100% 1TB memory - "if DLC"

DLC $187.26 savings per server / year

- All DLC and AIR estimates are based on 504 servers and assume no power constraints within a rack.
- DLC racks are populated with 84 servers.
- Estimated cooling costs are based on 10.5 cents per KW/h

SIGNIFICANT SAVINGS IN BOTH POWER CONSUMPTION AND FOOTPRINT

Air cooled data center cooling cost per server

$216.77/Server @ 18 servers per rack

DLC Cooled data center cooling cost per server

$29.74/Server/Year

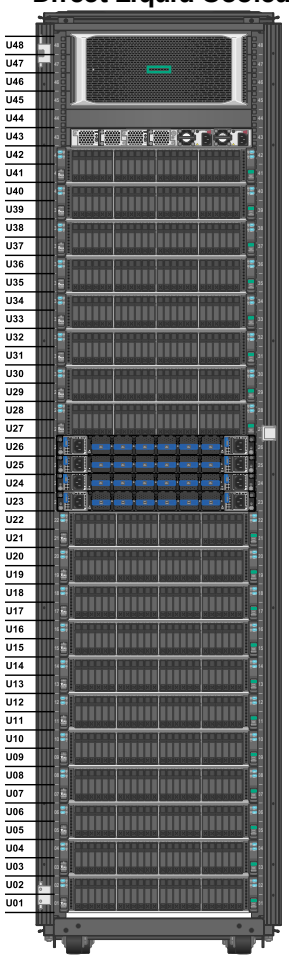
Liquid Cooled Savings

$1,870,300/Year *per 10,000 Servers in 2022/2023 new Grid*

= Add more servers with savings
= colo hall “small” power and cooling upgrades
= versus having to build a new hall for 500+ 15kW racks

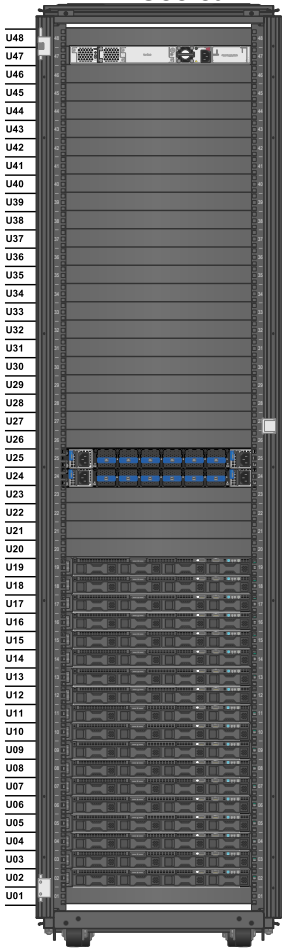
CPUs <240W; imagine how much worse air-cooled would be on space and fan power with higher power and lower Tcase CPUs

80 servers
Direct Liquid Cooled



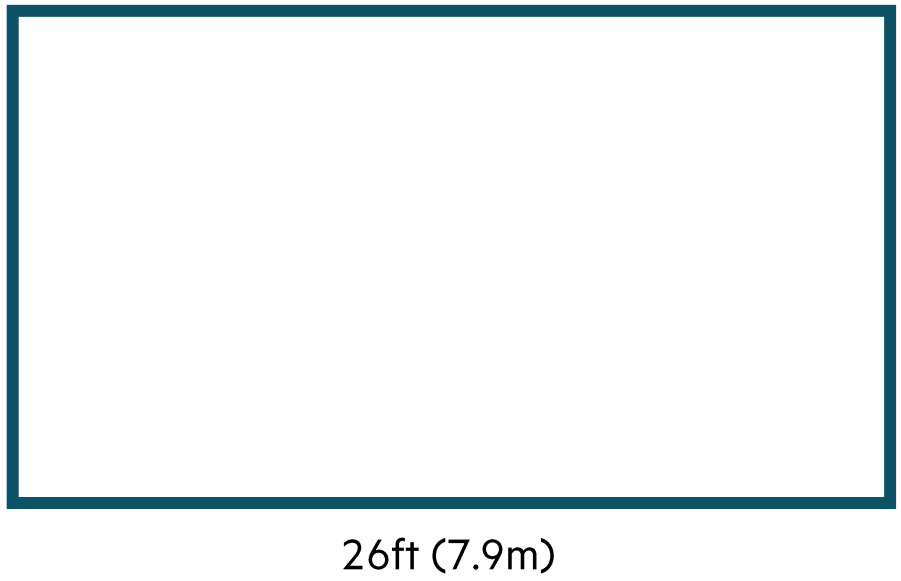
125 racks
DLC Cooled
10,000 servers

18 Servers
Air Cooled

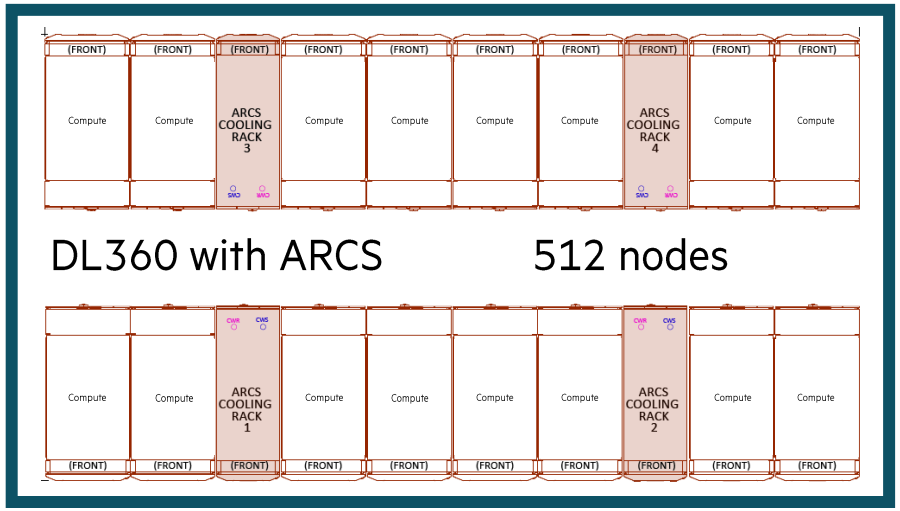


556 racks
Air Cooled
10,000 servers

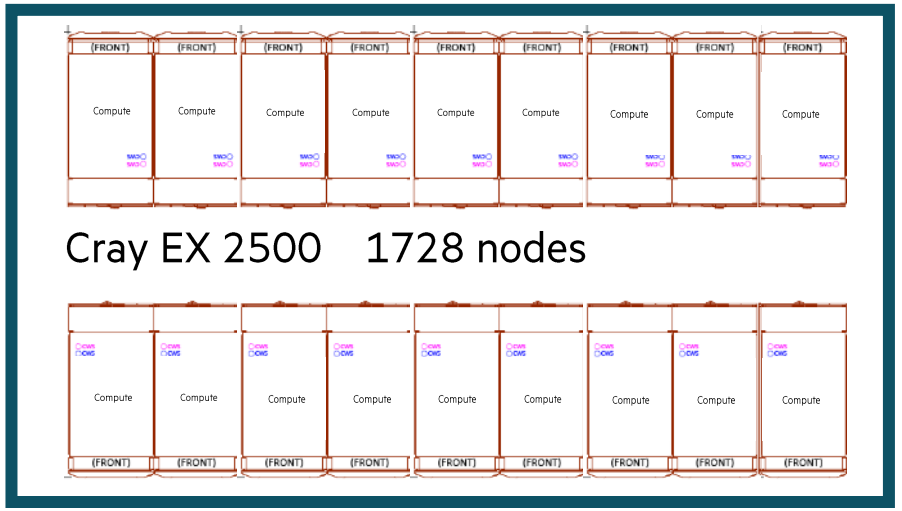
DENSITY COMPARISON – 14FT X 26FT (4.26M X 7.9M)



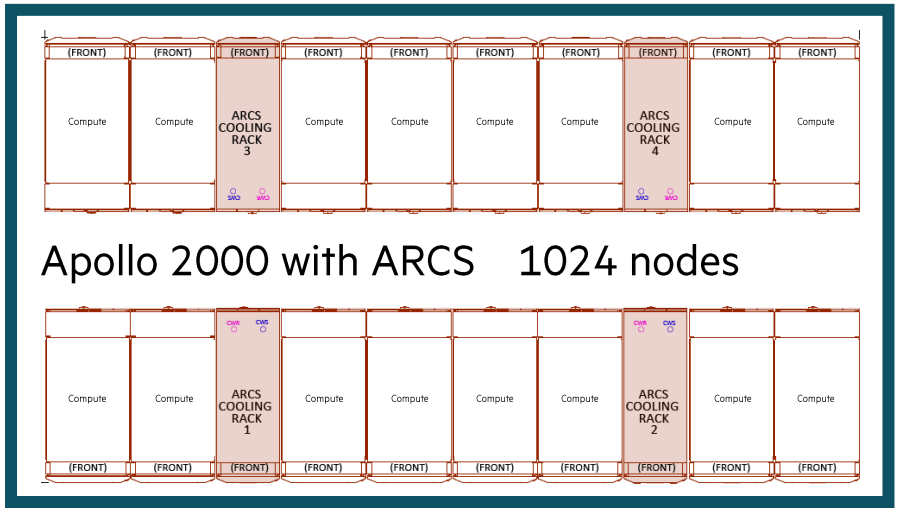
DENSITY COMPARISON – 14FT X 26FT (4.26M X 7.9M)



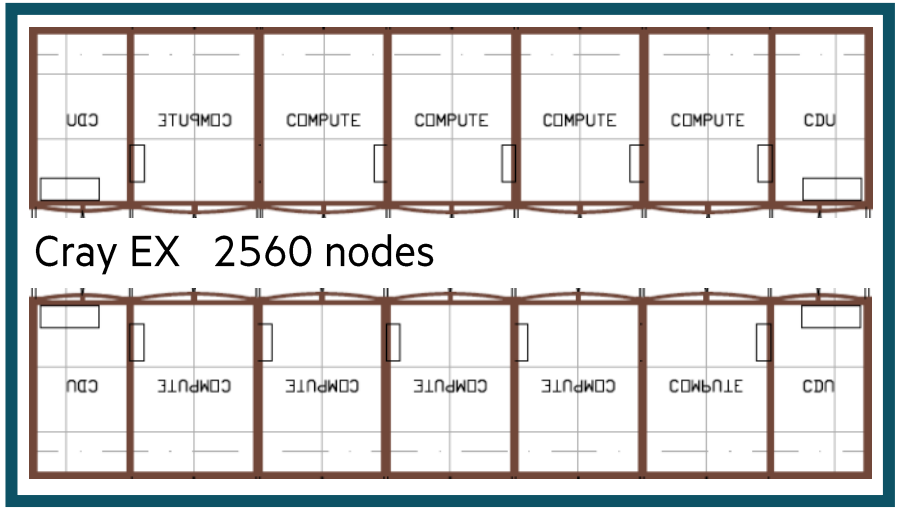
DL360 with ARCS 512 nodes



Cray EX 2500 1728 nodes



Apollo 2000 with ARCS 1024 nodes



Cray EX 2560 nodes

Q&A

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Wade Vinson wade.vinson@hpe.com

FINANCIAL OUTCOMES: Additional hardware through savings

CEO/CFO/CIO Mandates:

Less $$$ going to utilities
More $$$ producing flops

In chassis: PSU power, VRD power, fan power, pump power, CPU leakage power = ITUE
In data center: CRAH power, 2ndry pump power, chiller power, primary pump power, cooling tower power dry cooler power = pPUE
= TUE

+ Capex for all of the facility high power things avoided

Even more money to buy flops

DATA CENTER TCO SCENARIO 1—HIGHEST POWERED CPUS

- Rack:
  - 18 chassis = 72 nodes
- Node:
  - 280W Processor
  - 777W tray power draw (incl 32gb dimms and 50W in cards)
- Operational Performance
  - Air Cooled—85% fan speed, 500W fan dissipation per chassis, 125W per node
  - DLC—25% fan speed, 30W fan dissipation per chassis, 8W per node
- Data Center
  - Air Cooled—Chiller cooled data center with 1.45 pPUE for system. Highest powered processors require ambient temperatures ~20°C
  - DLC—Free cooled data center with 1.1 pPUE for system. Data center can operate up to 35C temperatures for ambient air and facility water to the CDU

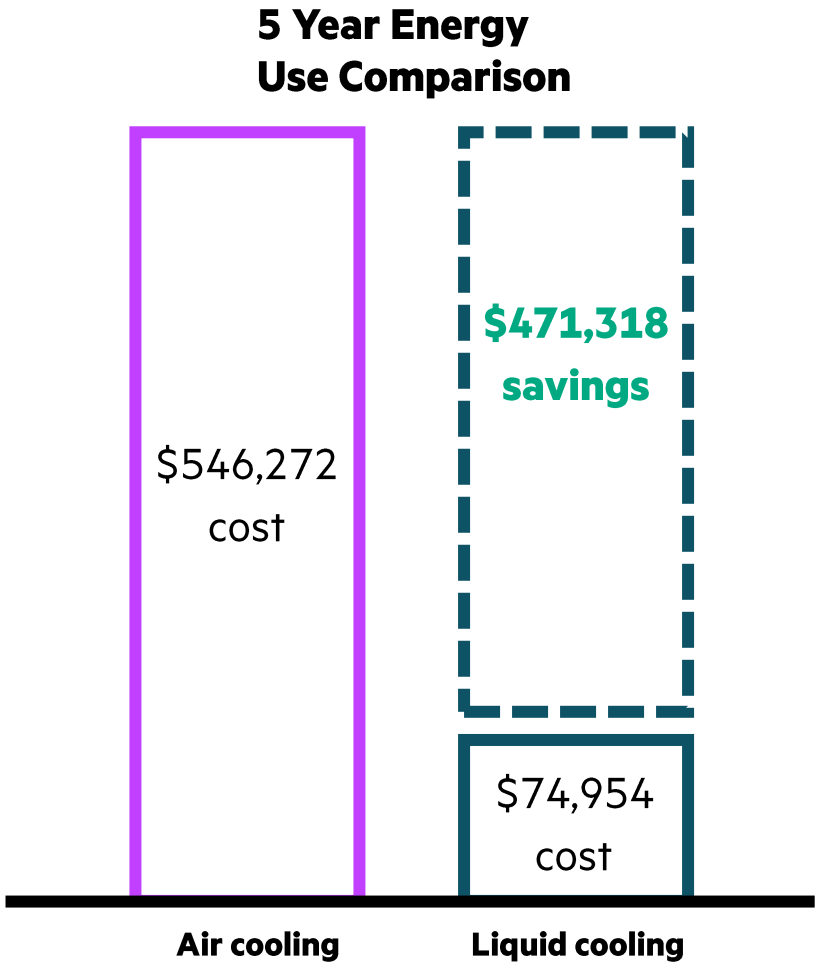
	DLC	Air Cooled	
Node Compute Power	777	777	W
Node Fan Power	8	125	W
Node PSU Losses	38	46	W
Per node power	823	948	W
Number of nodes	72	72	#
Rack Power (AC)	59.2	68.2	kW
Data Center pPUE for HPC System	1.1	1.45	#
Power Usage per Day	1563	2375	kWh
Cost per kWh	0.16	0.16	$USD
Energy Cost per Day	$ 250.15	$ 379.99	$USD
Energy Cost Difference per day		$ 129.84	$USD
Capital Cost	$ 28,303.00	$ -	$USD
Investment Payback (Days)	**218**		

DATA CENTER TCO SCENARIO 2—HIGH POWERED 240W CPU

- Rack:
  - 18 chassis = 72 nodes
- Node:
  - 240W Processor
  - 688W tray power draw (incl 32gb dimms and 50W in cards)
- Operational Performance
  - Air Cooled—75% fan speed, 360W fan dissipation per Chassis, 90W per node
  - DLC—25% fan speed, 30W fan dissipation per chassis, 8W per node
- Data Center
  - Air Cooled—Chiller cooled data center with 1.2 pPUE for system. High powered processors require ambient temperatures ~25°C
  - DLC—Free cooled data center with 1.1 pPUE for system. Data center can operate up to 35C temperatures for ambient air and facility water to the CDU

	DLC	Air Cooled	
Node Compute power	688	688	W
Node Fan Power	8	90	W
Node PSU Losses	33	38	W
Per node power	729	816	W
Number of nodes	72	72	#
Rack Power (AC)	52.5	58.7	kW
Approximate Data Center PUE	1.1	1.2	#
Power Usage per Day	1385	1691	kWh
Cost per kWh	0.16	0.16	$USD
Energy Cost per Day	$ 221.63	$ 270.61	$USD
Energy Cost Difference		$ 48.98	$USD
Capital Cost	$ 28,303.00	$ -	$USD
Investment Payback (Days)	**578**		

FINANCIAL OUTCOMES: Additional hardware through savings



7%
more
servers

can be purchased with liquid cooling energy savings over 5 years

Example compares air cooled DL360 Gen 10 to XL220N DLC servers
All Liquid cooling and Air cooling estimates are based on 6 racks with total of 504 servers and assume no power constraints within a rack.
Estimated cooling costs are based on 10.5 cents per KW/h over a 5 year period

MORE PERFORMANCE CPUS BEING ADOPTED AT SCALE = 32 CORE AVERAGE, 225W AVERAGE….. 40% AT 270/280W WITH LOWER TCASE?

- 65kW rack / 84 nodes = 800W /node – 280W CPU?
  - 1.5% fan tax = 10W fans
  - base= 639W node + PSU
- 75kW rack / 84 nodes = 1100W /node
  - base= 639W node + PSU, so 157W fans
  - fan tax =
  - 25C room – 48C outlet? : 51.4cfm/node
    - 4300cfm rack
    - 2 racks per ARCS?

THANK YOU

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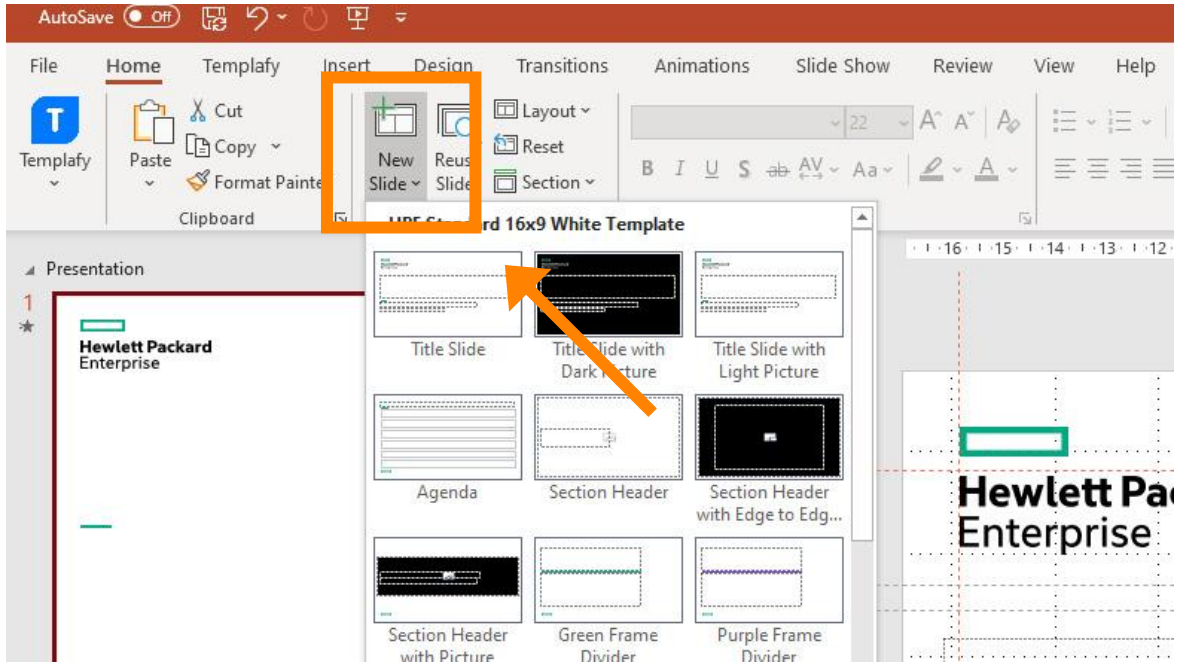
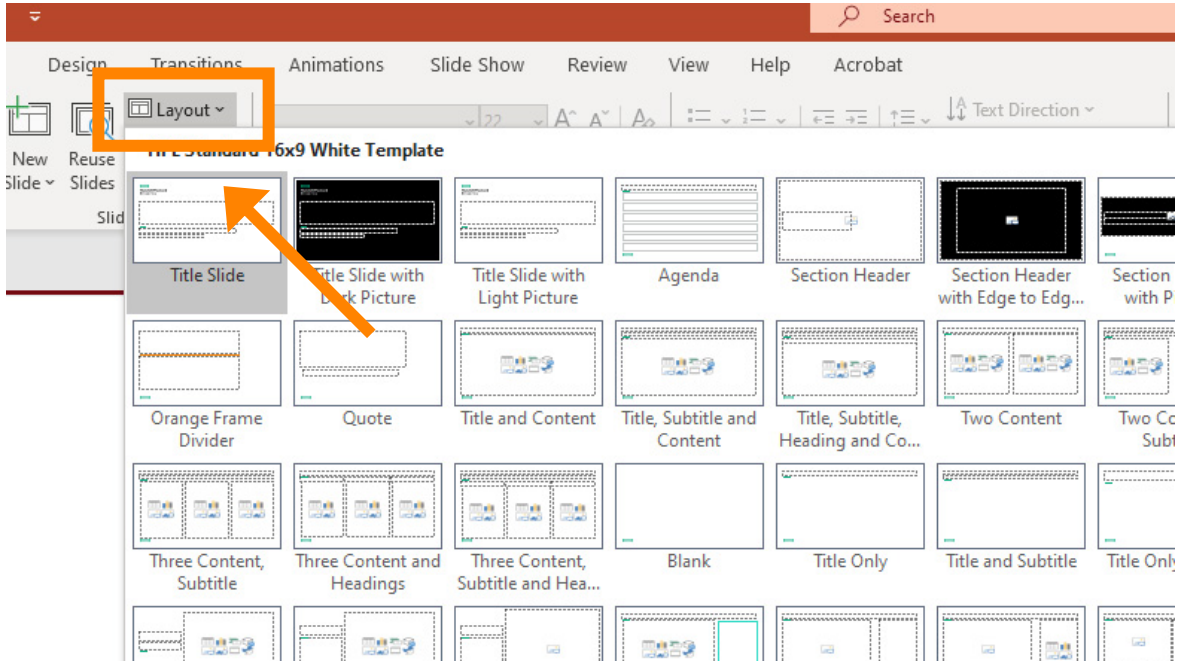


ADDING NEW SLIDE

Click on *New Slide* and select the layout that best supports your content.



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Switch layouts by clicking *Layout*.

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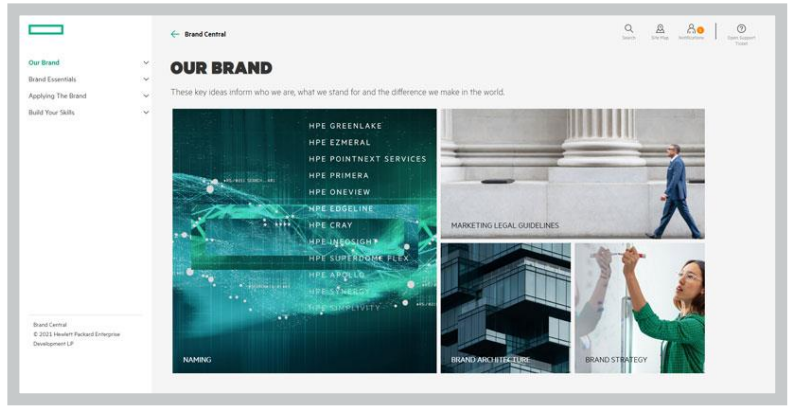

ACCESS BRAND CENTRAL

OPEN SUPPORT TICKET

OVER 150 INSPIRATION SLIDE GALLERY

POWERPOINT QUICK STEPS

CO-MARKETING POWERPOINT

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